Publication number : 2002-323687

Date of publication of application : 08.11.2002

Int.Cl. G02F 1/13 G02F 1/1341

Application number : 2001-128144

Applicant : HITACHI INDUSTRIES CO LTD

Date of filing : 25.04.2001

Inventor :

ISHIDA SHIGERU

KAWASUMI YUKIHIRO

HACHIMAN SATOSHI

MURAYAMA TAKAO

HIRAI AKIRA

ENDO MASATOMO

NAKAYAMA YUKINORI

METHOD AND DEVICE FOR ASSEMBLING LIQUID CRYSTAL SUBSTRATE

[Abstract]

PROBLEM TO BE SOLVED: To produce a liquid crystal panel without any display unevenness.

SOLUTION: The method for assembling liquid crystal substrates, by which one substrate 1b of substrates is held on a lower surface of a pressurizing plate 27 and another substrate 1a is held on a table 9, then a liquid crystal agent P is

supplied onto the other substrate 1a, subsequently a gap between the mutually confronted respective substrates 1a, 1b to stick them to each other with an adhesive disposed on either one of the respective substrates 1a, 1b, comprises a nozzle positioning step to position a tip of a nozzle 18b for discharging the liquid crystal agent with a specified height with respect to the surface of the substrate 1a and a liquid crystal agent applying step to apply the liquid crystal agent P on the other substrate 1a with a specified angle θ with respect to an alignment direction R of the substrate 1a and with at least a nearly linear application pattern set previously.

[Claims]

[Claim 1]

An assembly method of a liquid crystal substrate, wherein on one of two sheets of substrates being target adhesion subjects is supported by the bottom of a pressurization plate, the other substrate is supported on a table, a liquid crystal agent is supplied to the other substrate, a distance between the opposing substrates becomes narrow, and the substrates are adhered together using an adhesive provided on one of the substrates, the method comprising the steps of:

(a) deciding, on the top of the other substrate, the location of the front end of a nozzle for discharging the liquid crystal agent at a predetermined height toward a surface of the other substrate; and

(b) coating the liquid crystal agent on the other substrate in a coating pattern of at least one almost straight shape that is previously set at a predetermined angle to an orientation direction of the other substrate.

[Claim 2]

The assembly method as claimed according to Claim 1, wherein the step (b) is performed by supplying an inert gas to the circumference of the front end of the nozzle before the liquid crystal agent is coated, and coating the liquid crystal agent while discharging the liquid crystal agent and the inert gas at the same time.

[Claim 3]

The assembly method as claimed according to Claim 1 or 2, wherein UV type dry cleaning or ion blow cleaning is performed on a surface of the other substrate before the step (b).

[Claim 4]

An assembly apparatus of a liquid crystal substrate having a pressurization plate that supports one of two sheets of substrates being target adhesion subjects, a table that supports the other substrate and disposes the other of the substrates to one of the substrates, and liquid crystal supply means that supplies a liquid crystal agent on the other substrate, wherein one substrate and the other substrate to which the liquid crystal agent is supplied are adhered under pressurization within a decompression chamber, the assembly apparatus comprising:

a nozzle having liquid crystal supply means that discharges the liquid crystal agent on the other substrate;

a measurement unit that measures a distance between the plane of the other substrate and the nozzle; and

driving means that elastically supports the motion of the table for coating the liquid crystal agent on the nozzle almost straightly at a predetermined angle to an orientation direction of the other substrate.

[Claim 5]

The assembly apparatus as claimed according to Claim 4, wherein a liquid crystal agent discharge outlet of the nozzle has a porous serial shape for coating the liquid crystal agent in an almost straight shape having a predetermined width.

[Claim 6]

The assembly apparatus as claimed according to Claim 4 or 5, further including an inert gas supply hole, which discharges an inert gas to the nozzle before the liquid crystal agent is coated, and surrounds the discharge outlet that discharges the inert gas simultaneously with the coating the liquid crystal agent.

[Title of the invention]

METHOD AND DEVICE FOR ASSEMBLING LIQUID CRYSTAL SUBSTRATE

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to an assembly method of a liquid crystal substrate and assembly apparatus thereof, wherein substrates being target adhesion subjects with a liquid crystal agent therebetween are disposed opposite to each other, and a distance between the substrates are adhered with a narrow gap.

[0002]

[Description of the Prior Art]

In manufacturing a liquid crystal display panel, two sheets of glass substrates in which a transparent electrode or a thin film transistor array is disposed are adhered together with a very close distance of several μm (for example, 2 μm) using a sealant having a □ shape, which is provided at the outer edge of the substrates or an adhesive coated on a proper location of the outer circumference of the substrate (the substrates after adhesion is referred to as "cell"). Each of the substrates and a space formed by the sealant or the adhesive is sealed using liquid crystal.

[0003]

Conventionally, a substrate adhesion method when performing sealing of liquid crystal includes Japanese Unexamined Patent Application Publication No. Sho62-89025 discloses a method in which liquid crystal is dropped on one of substrates in which the sealant is patterned in a close pattern (a □ shape) so that

an inlet is not formed. Further, the other of the substrates is disposed on one of the substrates within the vacuum chamber, a distance between the other of the substrates and one of the substrates becomes narrow in the vacuum state, and the two substrates are pressurized and adhered together.

[0004]

[Means for Solving the Problem]

In the method disclosed in Japanese Unexamined Patent Application Publication No. Sho62-89025, however, a liquid crystal agent is dropped on substrates. Accordingly, there is a problem in that stain failure is generated due to deformation or breakage of a film plane, which is incurred by force among molecules which is generated between the film plane of the substrates and the liquid crystal agent, drop shock or repulsive power of the liquid crystal agent, which is accompanied by pressurization upon adhesion (more particularly, repulsive power accompanied by an increase in the viscosity of the liquid crystal agent), defective orientation and the like. Furthermore, if the gap between upper and lower substrates upon adhesion is narrow, there occur problems in that the interface of a dropped liquid crystal agent is generated and a stain is created. Moreover, this method has a problem in that moisture in air, impurities, etc. are confined between the adhered substrates and the liquid crystal agent due to the introduction of air when the liquid crystal agent is dropped. This generates an oxidization phenomenon, etc., causing dropped marks to remain on the substrates. In addition, there is a problem in that a stain is generated in an assembled liquid crystal panel by means of the dropped marks.

[0005]

Accordingly, the present invention has been made in view of the above problems, and it is an object of the present invention to provide an assembly method of a liquid crystal substrate and assembly apparatus thereof, wherein a liquid crystal panel not having dropped marks of a liquid crystal agent or a display stain by the interface of the liquid crystal agent upon adhesion can be manufactured.

[0006]

[Means for Solving the Problem]

In order to accomplish the object, according to the present invention, there is provided an assembly method of a liquid crystal substrate, wherein on one of two sheets of substrates being target adhesion subjects is supported by the bottom of a pressurization plate, the other of the substrates is supported on a table, a liquid crystal agent is supplied to the other of the substrates, a distance between the opposite substrates becomes narrow, and the substrates are adhered together using an adhesive provided on one of the substrates. The method includes the steps of deciding, on the top of the other of the substrates, the location of the front end of a nozzle for discharging the liquid crystal agent at a predetermined height toward a surface of the other of the substrates, and coating the liquid crystal agent on the other of the substrates in a coating pattern of at least one almost straight shape that is previously set at a predetermined angle to an orientation direction of the other of the substrates.

[0007]

[Embodiment of the Invention]

An assembly apparatus of a liquid crystal substrate according to an embodiment of the present invention will be described with reference to Figs. 1 to 3.

[0008]

The construction of the assembly apparatus of the liquid crystal substrate according to the present embodiment is shown in Fig. 1. The assembly apparatus of the liquid crystal substrate can mainly include a liquid crystal pattern coating unit S1 being a liquid crystal coating apparatus, a substrate junction unit S2 which has a pressurization plate 27 that supports an upper substrate 1b and pressurizes the upper substrate 1b onto a lower substrate 1a, and a XYθ stage T1 having a table 9 that supports the lower substrate 1a thereon. In this case, the liquid crystal pattern coating unit S1 and the substrate junction unit S2 are supported by a plurality of support poles that are erect on the mounting plate 2 and a frame 3 comprised of a horizontal member extending between the support poles, and are disposed adjacent to them. The XYθ stage T1 is disposed to move between the liquid crystal pattern coating unit S1 and the substrate junction unit S2, and the mounting plate 2. The construction of each of them will be described.

[0009]

The liquid crystal pattern coating unit S1 includes a dispenser 17 having a nozzle 18 that drops a desired amount of a liquid crystal agent on the lower substrate 1a (the principle surface of the lower substrate 1a) located on the table 9 to be described later, a Z-axis stage 15 that supports the dispenser 17 and moves it in the up and down direction (the Z-axis direction in Fig. 1), a motor 16 that elastically supports the up- and down-motion of the Z-axis stage 15, and a substrate surface height measurement unit LS disposed in the vicinity of the

dispenser 17 and supported by the Z-axis stage 15. The liquid crystal pattern coating unit S1 constructed above maintains the Z-axis stage 15 using a bracket 14 that is projected from the frame 3 to be described later, which supports the substrate junction unit S2.

[0010]

The dispenser 17 will be below described. The dispenser 17 is coupled to a pressure source (not shown) (for example, a pump) and an air filter (not shown). The inert gas such as nitrogen gas or argon gas, which is sent from the pressure source, passes through the air filter. The inert gas that does not contain impurities such as waste can be thus transferred. The inert gas is transferred to a gas supply unit 18a in which the dispenser 17 that contains the liquid crystal agent supplies the inert gas to the storage unit 17a and the lower substrate 1a, as shown in Fig. 3. As such, as the inert gas is supplied to the storage unit 17a, the liquid crystal agent is forcedly send. The liquid crystal agent a nozzle front-end portion 18b is thus coated on the lower substrate 1a. Further, the gas supply unit 18a covers the nozzle front-end portion 18b, and the inert gas is discharged in such a way to surround the nozzle front-end portion 18b. The front end (a liquid crystal agent discharge outlet) of the nozzle front-end portion 18b according to the present embodiment is almost circular. As such, since a dual nozzle is employed as such, the liquid crystal agent can be coated without being in contact with air as possible.

[0011]

In the case where the liquid crystal agent is coated using the above-described dispenser 17, the inert gas is generally discharged while coating the liquid crystal agent.

In this case, in the present embodiment, since the discharge of the inert gas begins before the liquid crystal agent is coated, air on the surface of the lower substrate 1a is removed. It is thus possible to further reduce a possibility that the liquid crystal agent can be in contact with air.

[0012]

The construction of the aforementioned substrate surface height measurement unit LS will be below described. The substrate surface height measurement unit LS serves to measures a time from when supersonic waves are radiated toward the principle surface of the lower substrate 1a until when its reflection waves return, and measure a distance between the substrate surface height measurement unit LS and the lower substrate 1a based on the measured time. The substrate surface height measurement unit LS can be used to adjust the location of the nozzle of the dispenser 17, as will be described later. That is, when moving the Z-axis stage 15 up and down so that the location of the nozzle become a desired height from the lower substrate 1a, a distance measured by the substrate surface height measurement unit LS is used.

[0013]

At this time, though not shown in Fig. 1, a dispenser for discharging a sealant is disposed near the dispenser 17 for dropping the liquid crystal agent. The dispenser for discharging the sealant is fixed to the frame 3 through a bracket (not shown) in the same manner as the dispenser 17 for dropping the liquid crystal agent.

[0014]

The substrate junction unit S2 includes an upper chamber unit 21 whose bottom consisting of a decompression chamber and the lower chamber unit 10 to

be described later is perforated, and a pressurization plate 27 that is disposed within the upper chamber unit 21 through a shafts 29 and has a suction adsorption device and an electrostatic adsorption device. The upper chamber unit 21 and the pressurization plate 27 move up and down independently.

[0015]

In particular, a through hole (not shown) through which a plurality of the shafts 29 penetrate is formed in the upper chamber unit 21. Further, on the top of the upper chamber unit 21 is formed a housing 30, which covers a gas between the through hole and the shafts 29 and has a linear bush and a vacuum seal covering the shafts 29 built in, and a cylinder 22, which fixes the body to the horizontal member of the frame 3 and fixes a member that reciprocally moves within the body in the up and down direction to the top of the upper chamber unit 21. Through this construction, the upper chamber unit 21 is moved in the up and down direction by means of the cylinder 22 using the shafts 29 as a guide.

[0016]

The vacuum seal of the above-described housing 30 is build so that vacuum leakage is not generated from a gap between the through hole and the shafts 29, although the upper chamber unit 21 and the lower chamber unit 10 are combined to form the decompression chamber and the housing 30 is thus deformed. For this reason, although load is applied to the shafts 29 due to the deformation of the decompression chamber, the vacuum seal can absorb the power. Further, the vacuum seal can also prevent deformation of the pressurization plate 27 fixed to one end of the shafts 29. Thus, upon adhesion of the substrates 1a and 1b as described above, the adhesion can be performed with

the upper substrate 1b fixed to the pressurization plate 27 and the lower substrate 1a fixed to the table 9 become parallel to each other.

[0017]

In this case, a flange 21a for performing air-tightening of the decompression chamber when the decompression chamber is formed together with the lower chamber unit 10 is disposed at the bottom (the circumference of the aperture) of the upper chamber unit 21.

[0018]

Further, on the side of one side of the upper chamber unit 21 are disposed a pipe horse 24 that communicates with the decompression chamber in order to decompress the decompression chamber, a vacuum valve 23 disposed in the middle of the pipe horse 24, and the vacuum pump (not shown) coupled to the pipe horse 24.

[0019]

Furthermore, on the side of the other side of the upper chamber unit 21 are disposed a gas purge valve 25 that communicates with the decompression chamber in order to return the inside of the decompressed decompression chamber to an atmospheric pressure, a gas tube 26 couple to one end of the gas purge valve 25, and a pressurization pump that is coupled to the other end of the gas tube 26 and transmits nitrogen, clean dry air, etc.

[0020]

In this case, on the upper chamber unit 21 is disposed a plurality of windows for monitoring positional matching marks of the substrates 1a and 1b through marks recognition holes (not shown) that are formed in the pressurization plate 27. At this time, an image recognition camera (not shown) disposed at an

upper side of the windows of the upper chamber unit 21 is used to monitor the positional matching marks. Deviation of the positional matching marks of the substrates 1a and 1b is measured by means of the image recognition camera.

[0021]

Thereafter, the pressurization plate 27 is fixed to one end of the shaft 29, as described above. In this case, the other end of the shaft 29 is fixed to the housing 31. The pressurization plate 27 is adapted to move up and down by means of the linear guide 34 disposed at both ends of the housing 31 and a guide member 3a disposed in the frame 3 that engages the linear guide 34. To be more precise, the pressurization plate 27 includes a housing 32 disposed on the housing 31, a load meter 33 disposed on a surface of the housing 32, a nut housing 37 which has an arm screw unit concaved in a spiral shape in the up and down direction and is disposed on the load meter 33, a ball screw 36 that is rotatably coupled to the arm screw unit of the nut housing 37, and a motor 40 which has an output axis and rotates a ball screw 36 around the axis. The motor 40 is driven to implement the up- and down-motion of the pressurization plate 27. At this time, the motor 40 is fixed to the bracket 38 on the frame 35 disposed on the frame 3.

[0022]

Through this construction, the motor 40 is driven to lower the pressurization plate 27 that supports the upper substrate 1b and to adhere the substrate 1b the lower substrate 1a on the table 9I, thus providing pressurization necessary for adhesion. In this case, the above-described load meter 33 operate as a pressurization sensor, and controls the motor 40 according to a feedback signal, thus providing desired pressurization to the substrates 1a and 1b.

[0023]

As described above, the pressurization plate 27 that moves up and down is provided with the suction adsorption device and the electrostatic adsorption device, as described above. The suction adsorption device includes a plurality of suction holes (not shown) formed from the bottom of the pressurization plate 27, a joint 41 for suction adsorption, which communicates with each of the suction hole and is disposed in the upper chamber unit 21, a suction tube 42 that communicates with the joint 41 for suction adsorption, and the vacuum pump (not shown) that is coupled to the suction tube 42. The suction adsorption device constructed above drives the vacuum pump under the atmosphere to adhere the upper substrate 1b to the bottom of the pressurization plate 27 by way of vacuum adsorption (or suction adsorption).

[0024]

Hereinafter, the electrostatic adsorption device will be described. The electrostatic adsorption device includes an almost square flat panel electrode in the present embodiment, and is mounted in each of two almost square concave portions formed at both ends of the bottom of the pressurization plate 27. Further, the flat panel electrode has its surface (a lower side of the pressurization plate 27) covered with dielectric substance. The principle surface of the dielectric substance confronts the bottom of the pressurization plate 27. As such, the flat panel electrode disposed in the pressurization plate 27 is coupled to positive or negative DC power through a proper switch. For this reason, if the positive or negative voltage is applied to each of the flat panel electrodes, negative or positive charges are caused in the principle surface of the dielectric substance. Further, the upper substrate 1b is electrostatically adsorbed to the pressurization plate 27 due to crone power generating between transparent electrode films

formed in the upper substrate 1b. In this case, the voltages applied to the electrostatic adsorption electrodes can have the same polarity or a different polarity.

[0025]

Furthermore, in the case of the atmosphere, suction adsorption can be preferably performed using the aforementioned suction hole. This is because if electrostatic adsorption is performed, a discharge phenomenon is generated due to static electricity, damaging the upper substrate 1b or the pressurization plate 27 when an air layer exists between the upper substrate 1b and the pressurization plate 27. For this reason, for example, since the circumstance is under the atmosphere when the upper substrate 1b is first adhered to the pressurization plate 27, it is preferred suction adsorption is first performed by the suction adsorption device, and electrostatic adsorption is then performed after a decompression chamber is decompressed to the degree where the discharge phenomenon is not generated while the decompression room is decompressed.

[0026]

In this case, as will be described later, if the decompression chamber is decompressed in a state where the upper substrate 1b undergoes suction adsorption in the pressurization plate 27, there is a possibility that adsorption force thereof becomes weak and the upper substrate 1b may drop. Due to this, a container ring 60 for containing the upper substrate 1b at a location right below the pressurization plate 27 is disposed in. The container ring 60 is disposed corresponding to two edges being diagonal locations of the upper substrate 1b, and is supported by a shaft 59 extending from the upper chamber unit 21 to the bottom thereof.

[0027]

In particular, though not shown in the drawing, the shaft 59 is inserted into a through hole formed on the upper chamber unit 21. The shaft is constructed to rotate around the shaft 59 about its axial center and to move up and down. In this case, the shaft 59 is surrounded with a vacuum seal in order to prevent vacuum leakage from occurring in the decompression chamber. The rotation is performed by a rotary actuator (not shown) coupled to the end of the shaft 59, and the up and down motion is carried out by an elevation actuator (not shown) coupled to the end of the shaft 59 in the same manner. As such, as the shaft 59 is rotated and moved up and down, the substrates 1a and 1b are adhered. The container ring 60 can be removed so that the liquid crystal agent dropped on the lower substrate 1b does not interfere the diffusion of the principle surface of the substrates 1a and 1b when the liquid crystal agent diffuses.

[0028]

The construction of the XYθ stage T1 will be then described. The XYθ stage T1 includes a X stage 4a disposed on the mounting plate 2, a Y stage 4b disposed on the X stage 4a, a θ stage 4c disposed on the Y stage 4b, a table 9 which is disposed on the θ stage 4c and supports the lower substrate 1a thereon, and a lower chamber unit 10 that is fixed to the Y stage 4b through a plate 13 and has an upper side which forms the decompression chamber together with the upper chamber unit 21 perforated.

[0029]

The X stage 4a according to the present embodiment is constructed to move the Y stage 4b, the θ stage 4c, the table 9 and the lower chamber unit 10 in the left and right direction (the X-axis direction in Fig. 1), i.e., in a reciprocal

motion at the bottom of the liquid crystal pattern coating unit S1 and the substrate junction unit S2 by means of the driving motor 5. Furthermore, the Y stage 4b is constructed to move the θ stage 4c, the table 9 and the lower chamber unit 10 in the forward and backward direction (the Y-axis direction in Fig. 1) by means of the driving motor 6. More particularly, the θ stage 4c is constructed to rotate in the θ direction shown in Fig. 1 against the Y stage 4b by means of the diving motor 8 through a rotary bearing 7. In this case, the θ stage 4c is disposed to rotate against the lower chamber unit 10 through the rotary bearing 11 and the vacuum seal 12. Thus, although the θ stage 4c rotates, the lower chamber unit 10 is not moved.

[0030]

In this case, the lower substrate 1a is disposed in the gravity direction on the table 9. Thus, in order to contrive positional decision of the lower substrate 1a, the table 9 includes a positional decision device including a plurality of positional decision members 81 disposed corresponding to neighboring two circumferences of the lower substrate 1a, and a plurality of compression rollers 82 disposed corresponding to the remaining two circumferences of the lower substrate 1a, as shown in Fig. 2. The compression rollers 82 are adapted to move on the table 9 in an arrow direction shown in Fig. 2. It compress the lower substrate 1a to the positional decision members 81 using the compression rollers 82, thereby performing positional decision in a horizontal direction (a surface direction of the table 9) of the lower substrate 1a and performing the support on the table 9.

[0031]

At the time of fine positional decision right before the substrates 1a and 1b are adhered together, however, there is a possibility that the lower substrate 1a

can be deviated or rises high since the upper substrate 1b is in contact with the sealant or the liquid crystal agent on the lower substrate 1a. Further, when the decompression chamber is decompressed, the air between the lower substrate 1a and the table 9 can exist during the decompression process. This may cause the lower substrate 1a to deviate. For this reason, a suction adsorption device and an electrostatic adsorption device that are constructed in the same manner as the aforementioned pressurization plate 27 are provided in the table 9. Thereby, the lower substrate 1a can be closely adhered on the table 9.

[0032]

In this case, a plurality of pins (not shown), which is projected from a mounting surface of the lower substrate 1a and can move in the up and down direction, is disposed in the table 9. The table 9 raises the pins and pushes up the substrates after adhesion. This facilitates extraction from the table 9. Further, for example, when each of the pins is raised, it is contact with the table 9 and becomes a ground state. It is thus possible to remove electricity of the substrates after adhesion.

[0033]

In the lower chamber unit 10 are provided an O-ring 44 disposed at an upper side (the circumference of the aperture) and a ball bearing 87 disposed outside the O-ring 44. As such, since the O ring 44 is provided, when the upper chamber unit 21 is lowered to make the flange 21a in contact with the O ring 44, the chamber units 10 and 21 are integrated and thus serve as a decompression chamber, as will be described later. Further, the ball bearing 87 can be set to a predetermined location of the up and down direction in order to control the compression amount of the O ring 44 when the decompression chamber is

decompressed. As such, by properly adjusting the location of the ball bearing 87, force applied by decompression can be applied to the lower chamber unit 10 via the ball bearing 87. Further, since the ball bearing 87 is disposed, elastic deformation of the O-ring 44 is made possible. Thus, upon adhesion to be described later, the XYθ stage T1 can be easily moved within the elastic range of the O ring 44, so that positional decision can be performed accuracy.

[0034]

The operation of the assembly apparatus of the liquid crystal substrate according to the present embodiment will now be described.

[0035]

After a tool (not shown) that supports the upper substrate 1b is first laid in the table 9 using the hand of the moving machine, the driving motor 5 is driven to move the X stage 4a, thus moving the XYθ stage T1 below the substrate junction unit S2. Further, the motor 40 is driven to lower the pressurization plate 27. The upper substrate 1b of the table 9 is adsorbed to the pressurization plate 27. Thereafter, the motor 40 is driven to raise the pressurization plate 27, and the upper substrate 1b keeps supported by the pressurization plate 27.

[0036]

If the support of the upper substrate 1b to the pressurization plate 27 is finished, the driving motor 5 is driven to move the XYθ stage T1 below the liquid crystal pattern coating unit S1. Further, the tool that is empty from the table 9 is released to locate the lower substrate 1a on the table 9 using the hand of the moving machine. The lower substrate 1a is positioned in the positional decision members 81 and the compression rollers 82 shown in the aforementioned Fig. 2.

[0037]

At this time, since the rubbing direction of each of orientation films provided in the substrates 1a and 1b is generally disposed almost in a perpendicular way, it is necessary to consider the rubbing direction of each of the substrates 1a and 1b so that the liquid crystal agent can diffuse upon adhesion when supplying a liquid crystal agent to a predetermined area (location). That is, if the shape of a supplied liquid crystal agent is long and narrow in an approximately perpendicular direction to the orientation direction, the liquid crystal agent almost uniformly spreads. As such, the reason why the liquid crystal agent is coated in consideration of the rubbing direction is that since the liquid crystal agent easily flows in the rubbing (orientation) direction, a time until the liquid crystal agent reaches a sealant is made almost uniform regardless of its direction and a side where the liquid crystal agent slowly spreads becomes close to the sealant. For this reason, diffusion of a liquid crystal agent upon adhesion is taken into consideration, and a pattern having a tilt of a predetermined angle to the orientation direction of the lower substrate 1a, as will be described later is formed, is formed. Thus, spreading of the liquid crystal agent upon completion of adhesion becomes almost uniform.

[0038]

In view of the above, each of the substrates 1a and 1b is located on the table 9 such that its rubbing direction has a predetermined angle to the coating direction of the liquid crystal agent (e.g., an X-axis direction shown in Fig. 1 in the present embodiment.

[0039]

As described above, after the lower substrate 1a is supported on the table 9, ion blow is performed using the ion blow means IB shown in Fig. 1 in order to

improve the wettability of the liquid crystal agent on a surface of the lower substrate 1a. Ion blow is for cleaning the surface of the substrate and improving the wettability of the liquid crystal agent, by blowing ionization supersonic air onto the surface of the lower substrate 1a. In this case, dry cleaning can be performed by means of an UV type dry cleaner UVL shown in Fig. 1 instead of ion blow. There is, however, a possibility that dry cleaning can have a bad influence on a sealant to be described later (solidify a sealant) if it is performed after the sealant is coated. It is thus preferred that dry cleaning is performed before the sealant is coated. Meanwhile, in the case where ion blow is employed, there is no problem if it is performed after the sealant is coated.

[0040]

The driving motors 5 and 6 are driven to move the X stage 4a and the Y stage 4b. While the XYθ stage T1 is moved in the X-axis and Y-axis direction, the dispenser for supplying a sealant discharges the sealant on the lower substrate 1a. At this time, a sealant having a close pattern such as a □ shape is coated on the lower substrate 1a. As such, after the sealant is coated, the dispenser 17 discharges a necessary amount of a liquid crystal agent within the circumference consisting of the sealant. A method of coating the liquid crystal agent will be described in detail.

[0041]

The height (a discharge height of the liquid crystal agent P) of the nozzle front-end portion 18b, wherein the liquid crystal agent P is coated on the lower substrate 1a, is measured using the aforementioned substrate surface height measurement unit LS provided in the vicinity of for coating the liquid crystal agent. The motor 16 is driven to move the Z-axis stage 15 up and down, based on

the measurement value. The nozzle front-end portion 18b of the dispenser 17 is positioned at a predetermined height. In the present embodiment, the height of the nozzle front-end portion 18b is set about 10 to 20 μm lower than the height of the sealant (the height of 20 to 30 μm in the present embodiment). As such, if the discharge height of the liquid crystal agent P is set lower than that of the sealant, repulsive power acting between the substrates 1a and 1b can be mitigated by means of the liquid crystal agent P when the substrates are pressurized upon adhesion. It is also possible to reduce shock power when dropping a liquid crystal agent as in the prior art. Generation of a stain can be also prevented. Since the height of the liquid crystal agent P supplied becomes low, an adhesion time can be shortened.

[0042]

Next, while moving the lower substrate 1a in the X-axis or Y-axis direction by moving the X stage 4a or the Y stage 4b, the liquid crystal agent P is discharged from the nozzle front-end portion 18b and is coated around the central portion on the principle surface of the substrate 1a in a predetermined pattern.

[0043]

In the coating pattern of the liquid crystal agent in the present embodiment, as shown in Fig. 4(a), the liquid crystal agent P is coated within the pattern of a close sealant in the straight shape at the height where the aforementioned nozzle front-end portion 18b is set. The coating direction at this time is about an angle of θ (e.g., about 30 to 60 degree) to the orientation direction R (a rubbing direction) of the orientation film of the lower substrate 1a. In this case, the coating amount of the liquid crystal agent P is almost the same as the volume between each of the substrates 1a and 1b and the sealant when the substrates are completely adhered.

Furthermore, the coating direction of the liquid crystal agent P is preferably 45 degree to the orientation direction if the liquid crystal agent P spreads when the substrates are adhered. As such, as the liquid crystal agent P is continuously discharged to coat the lower substrate 1a, the supply time of the liquid crystal agent P can shorten.

[0044]

In this case, it is preferred that before the liquid crystal agent P is discharged, only an inert gas is previously supplied from the gas supply unit 18a, a surface of the lower substrate 1a is kept in an inert gas atmosphere, and the liquid crystal agent P is coated while discharging the liquid crystal agent P and the inert gas at the same time. As such, if the liquid crystal agent P is coated during the inert gas atmosphere, it is possible to prevent introduction of moisture in the atmosphere or an impurity, and oxidization of the liquid crystal agent P. Further, the liquid crystal agent P can be widely wet by way of the action of the discharged inert gas and can have the height lower than that of the liquid crystal plane. It is thus possible to further shorten the adhesion time of substrates. Further, a heater HT shown in Fig. 2 is disposed in the table 9, and the heater HT heats the lower substrate 1a. The viscosity of the coated liquid crystal agent P can be lowered and the height of the liquid crystal plane can be lowered.

[0045]

At this time, as described above, after the liquid crystal agent P is coated, ion blow can be performed on the surface of the substrate 1a. Therefore, the lower substrate 1a has a further lowered wettability of the liquid crystal agent. The liquid crystal agent can rapidly expand to the cross section of the sealant compared to a case where ion blow is not performed. Furthermore, the liquid crystal agent P can

be coated, while exciting the lower substrate 1a. This can further mitigate shock power when a liquid crystal agent is dropped as in the prior example, and the action of surface tension between the liquid crystal agent and the lower substrate 1a easily disappears. It is therefore possible to further prevent generation of a stain.

[0046]

Though description has been omitted, a spacer is previously sprayed or attached to the upper substrate 1b or the lower substrate 1a. At this time, the spacer serves to prevent a gap between the substrates 1a and 1b from becoming over a predetermined value when the substrates 1a and 1b are adhered. Further, in a state where the spacer is mixed in the liquid crystal agent, the spacer can be sprayed together with the coating of the liquid crystal.

[0047]

As described above, after a necessary amount of the liquid crystal agent is dropped, the driving motor 5 is driven to move the XYθ stage T1 at a predetermined location below the substrate junction unit S2. Further, if the XYθ stage T1 is stopped, the cylinder 22 is driven to lower the upper chamber unit 21 and to cause the flange unit 21a to be in contact with the O ring 44. The decompression chamber consisting of the lower chamber unit 10 and the upper chamber unit 21 is thus completed.

[0048]

After the decompression chamber is formed, the vacuum valve 23 is opened to decompress the decompression chamber. At this time, since the upper substrate 1b is adsorbed to the pressurization plate 27 as described above, suction adsorption force that is being applied to the substrate 1b becomes small

while the decompression chamber is decompressed. The upper substrate 1b cannot be maintained and the upper substrate 1b drops due to its weight. Due to this, the contain ring 60 shown in Fig. 2 is moved by means of the aforementioned rotary actuator or the elevation actuator. The upper substrate 1b is contained in the contain ring 60 and is then supported at a location right below the pressurization plate 27.

[0049]

When the decompression chamber is sufficiently decompressed (about 5×10^{-3} Torr in the present embodiment), a voltage is applied to the electrostatic adsorption device provided in the pressurization plate 27. The upper substrate 1b on the contain ring 60 is supported in the pressurization plate 27. At this time, since the decompression chamber is significantly decompressed and the air does not exist between the pressurization plate 27 and the upper substrate 1b, discharge by static electricity is not generated. Furthermore, a phenomenon that the upper substrate 1b rises high, which occurs when the air exists, is not generated.

[0050]

If the upper substrate 1b is electrostatically adsorbed, the shaft 59 is lowered by the elevation actuator and is then rotated by the rotary actuator, so that the contain ring 60 is evacuated not to hinder adhesion of the substrates 1a and 1b. Further, the motor 40 is driven to lower the pressurization plate 27, and the upper substrate 1b is made approach the lower substrate 1a. Thereafter, the positional matching marks provided in the substrates 1a and 1b are read using the image recognition camera, and positional deviation is measured through an image process. The operation of the X stage 4a, the Y stage 4b and the θ stage 4c

is controlled based on the measurement, and the table 9 is moved. Thus, the lower substrate 1a and the upper substrate 1b can be positioned with high accuracy. In this case, since the ball bearing 87 as described above is provided in the lower chamber unit 10, the ball bearing 87 can maintain the distance between the chamber units 10 and 21 as the table 9 is moved. It is also possible to maintain the vacuum state (a decompression state) without significantly changing the O-ring 44.

[0051]

If the positioning is finished, the pressurization plate 27 is further lowered and the bottom of the upper substrate 1b becomes in contact with the sealant on the lower substrate 1a. At this time, while the load meter 33 measures pressurization applied to the sealant, the driving force of the motor 40 is controlled to adhere the substrates 1a and 1b at a predetermined distance. In this case, since the upper substrate 1b is adhered to the pressurization plate 27 by means of electrostatic adsorption force, the center of the upper substrate 1b does no sink. Accordingly, it does not have a bad influence on the spacer in the liquid crystal agent, or defective positioning among the substrates 1a and 1b does not occur.

[0052]

In this case, if the area of the adhered substrates increases, the sealant cannot be sufficiently adhered only with adhesion by the aforementioned pressurization force. Due to this, if adhesion (first pressurization) by pressurization force is completed, electrostatic adsorption of the pressurization plate 27 is released and the cylinder 22 is driven to raise the upper chamber unit 21. The vacuum valve 23 is then closed and the gas purge valve 25 is opened to

supply nitrogen gas or clean dry air to the vacuum chamber, returning the vacuum chamber to the atmospheric pressure. As such, since the vacuum chamber returns to the atmospheric pressure, pressure is applied to the liquid crystal substrates, so that the substrates can be surely adhered to a desired thickness (second pressurization).

[0053]

At this time, when the pressure within the vacuum chamber changes from the vacuum state to the atmospheric pressure, high pressure is uniformly applied to the substrates 1a and 1b from the outside since a space portion between liquid crystal agents between the substrates 1a and 1b is in the vacuum state. For example, if the atmospheric pressure is applied when the space portion between the substrates 1a and 1b is in the vacuum state, power of 121.6 kN can be applied. The main pressurization performs adhesion using the pressure applied to each of the substrates 1a and 1b.

[0054]

If the adhesion is completed, the gas purge valve 25 is closed and the XYθ stage T1 returns below the liquid crystal pattern coating unit S1. The adhered substrates are taken out from the table 9 using the hand of the moving machine. Adhesion of next substrates is then prepared. The substrates that are taken out after the adhesion are sent to an UV light radiation device or a heating device in order to harden the sealant.

[0055]

As described above, in the present embodiment, immediately after a sealant is coated and a liquid crystal agent is dropped, the process can proceed to an adhesion process. Thus, dust is not easily attached to the substrates before

adhesion. Further, due to this, defective parts, which are incurred by dropped marks as in the prior example, are not easily generated in the substrates after the adhesion. This can also improve the yield.

[0056]

Furthermore, since an exact amount of a liquid crystal agent can be supplied, it is possible to prevent waste of the liquid crystal agent. There is also no possibility that substrates can be contaminated since the liquid crystal agent overflows the outside of a pattern of a sealant. In this case, as there is no need for a cleaning process of contaminated substrates, the productivity can be further improved.

[0057]

Furthermore, the XYθ stage T1 that supports the lower substrate 1a thereon can be used to return the upper chamber unit 21 of the upper substrate 1b. It is thus possible to miniaturize an assembly apparatus even without using other equipment for returning the upper substrate 1b.

[0058]

Furthermore, the present invention is not limited to the above embodiment, but can be implement as follows.

(1) In the present embodiment, it has been described that the liquid crystal pattern coating unit S1 and the substrate junction unit S2 are disposed on the common mounting plate 2. An apparatus that can coat both a sealant and a liquid crystal agent can be constructed separately from an apparatus that performs adhesion. Further, a sealant coating apparatus and a liquid crystal agent coating apparatus can be constructed separately.

(2) A relative motion direction among substrates, which expands a liquid crystal agent, can be a circular shape or a spiral shape if the liquid crystal agent does not overflow a pattern of a sealant.

(3) In the present embodiment, a method of locally supplying an inert gas from a nozzle has been described. The whole assembly apparatus can be disposed within a chamber of an inert gas atmosphere or within a decompression chamber. Thus, a dropping atmosphere of the liquid crystal agent can becomes an inert gas or vacuum (decompression) state.

(4) In the present embodiment, it has been illustrated that the circumference of the dispenser 17 is surrounded with the cover 17k and locally supplies an inert gas. However, the whole assembly apparatus can be disposed within a chamber of the inert gas atmosphere or a decompression chamber, so that the drop atmosphere of the liquid crystal agent becomes an inert gas or vacuum (decompression) state.

[0059]

In this case, the coating pattern of the liquid crystal agent can be performed as follows instead of that shown in Fig. 4(a).

[0060]

Firstly, as shown in Fig. 4(b), a plurality of straight pattern of the liquid crystal agent P shown in Fig. 4(a) is patterned (coated). At this time, the coating direction of the liquid crystal agent P is an angle θ to the rubbing direction (orientation direction) R as in the coating pattern of the liquid crystal agent shown in Fig. 4(a). By making the liquid crystal agent have the coating pattern, a sufficient amount of the liquid crystal agent P can be supplied to the lower

substrate 1a although a distance between the nozzle front-end portion 18b and the lower substrate 1a becomes small. Further, since the height of the liquid crystal agent P can be further lowered, a stain can be prevented or an adhesion time can be shortened. At this time, a timing where adhesion of substrates is performed is preferably after a plurality of coated lines of the liquid crystal agent P is diffused within the pattern of the sealant and closed.

[0061]

Secondly, as shown in Fig. 4(c), the liquid crystal agent P is coated almost in a cross shape. The reason why the liquid crystal agent P is coated almost in a cross shape is for allowing the liquid crystal agent P to easily diffuse upon adhesion of substrates because the upper substrate 1b and the lower substrate 1a are almost perpendicular to the rubbing direction R. This coating pattern of the liquid crystal agent is effective in coating the liquid crystal agent P in a direction identical to the rubbing direction R because the liquid crystal agent P can easily diffuse although the rubbing direction (the orientation direction) R is coincident with the coating direction of the liquid crystal agent P, as shown in Fig. 4(c).

[0062]

Thirdly, as shown in Fig. 4(d), the liquid crystal agent P is coated almost straightly (almost square) with a wide width. In this case, the nozzle front-end portion having the discharge outlet of the porous serial shape in which a plurality of liquid crystal agent discharge outlet holes is disposed in series can be employed instead of the nozzle front-end portion 18b of the above almost circular discharge outlet. The coating direction of the liquid crystal agent P is coated at an angle θ to the rubbing direction (the orientation direction) R as in the liquid crystal agent coating pattern shown in Fig. 4(a). By coating the liquid crystal

agent P using the nozzle front-end portion, it is not necessary to discharge the liquid crystal agent P by changing the discharge location several times as shown in Fig. 4(b) in order to supply a desired amount of the liquid crystal agent P. It is also possible to shorten the supply time of the liquid crystal agent P. Furthermore, a sufficient amount of the liquid crystal agent P can be supplied to the lower substrate 1a if a distance between the nozzle front-end portion 18b and the lower substrate 1a is small. It is thus possible to further lower the height of the liquid crystal agent P and also to prevent a stain or shorten the adhesion time.

[0063]

[Effect of the Invention]

According to the present invention in accordance with an assembly method of a liquid crystal substrate and assembly apparatus thereof, it is possible to prevent generation of a strain due to deformation or breakage of a film plane, which is incurred by molecular power generating between the film plane of substrates and a liquid crystal agent, drop shock or repulsive power of the liquid crystal agent that is accompanied by pressurization upon adhesion, which is generated by dropping the liquid crystal agent on the substrate in a conventional example. Furthermore, since it is possible to prevent generation of an interface of the liquid crystal agent that is dropped in a state where upper and lower substrates have a narrow gap in an adhesion process, generation of a strain can be prevented. Further, since it is possible to prevent the introduction of moisture in air, an impurity, etc., which generate an oxidization phenomenon, etc. and thus generate dropped mark when supplying a liquid crystal agent, a strain incurred by the dropped marks can be prevented.

[Description of Drawings]

Fig. 1 is a partial cross-sectional view showing the construction of an assembly apparatus of a liquid crystal substrate according to an embodiment of the present invention.

Fig. 2 is a perspective view illustrating a contain ring of an upper substrate or a positional decision device of a lower substrate according to the present embodiment.

Fig. 3 is an explanatory view showing the construction of a nozzle portion of a dispenser for supplying a liquid crystal agent according to the present embodiment.

Fig. 4 is a surface view showing a coating pattern of a liquid crystal agent when viewed from the top of a lower substrate. Fig. 4(a) is an explanatory view showing a pattern of an almost straight shape, Fig. 4(b) is an explanatory view showing plural lines of the pattern of the almost straight shape shown in Fig. 4(a), Fig. 4(c) is an explanatory view showing a pattern of an almost cross shape, and Fig. 4(d) is an explanatory view showing a pattern of an almost straight shape having a wide width.

[Explanation of Numerals]

1a: Lower substrate (the other of substrates)

1b: Upper substrate (one of substrates)

9: Table

17: Dispenser (liquid crystal supply means)

18: Nozzle

18a: Gas supply unit

18b: Nozzle front-end portion

27: Pressurization plate

P: Liquid crystal agent

R: Rubbing direction (orientation direction)

θ : Angle

T1: XYθ stage (driving means)

LS: Substrate surface height measurement unit

IB: Ion blow means

UVL: UV type dry cleaner